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(54) Information processing method

(57) Main image information (101) representing a portrait face image of a person is prepared. Predetermined pattern image information (102), used as sub image information, is also prepared. Synthetic image information (103) is prepared by synthesizing the main image information (101) with the pattern image information (102) in such a manner that the pattern image information (102) is embedded in the main image information (101) in a state that is not recognizable to the eye of a human being. This synthetic image information (103) is recorded on an ID card (105) or the like as a visible image.

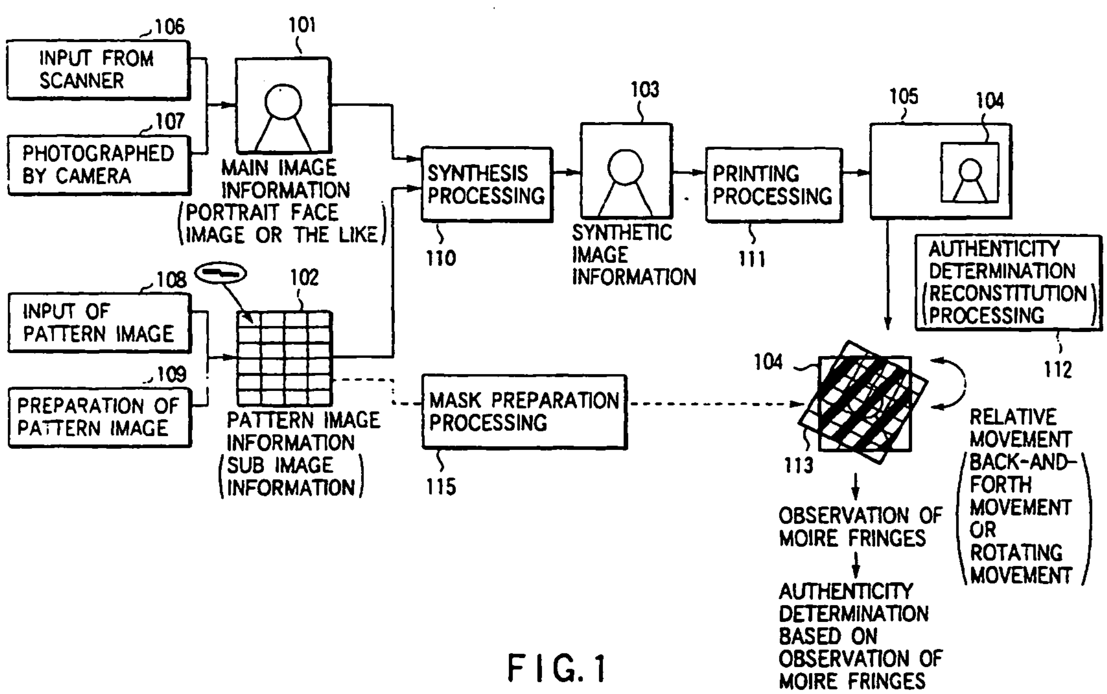

FIG.1

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image information that is recognizable to the naked eye of a human being; a second step of preparing sub image information by preparing first pattern image information and second pattern image information different from the first pattern image information, and by assigning the first and second pattern image information to the main image information such that the first pattern image information is assigned to an area corresponding binary image information representing a character or a symbol and such that the second pattern image signal is assigned to a background area which is other than the area corresponding to the character or the symbol; a third step of preparing synthetic image information by synthesizing the sub image information prepared in the second step with the main image information prepared in the first step, such that the synthesized state is not recognizable to the naked eye of the human being; and a fourth step of recording the synthetic image information, prepared in the third step, on a recording medium as a visible image.

[0014] This summary of the invention does not necessarily describe all necessary features so that the invention may also be a sub-combination of these described features.

[0015] The invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a flowchart illustrating the overall flow of the information processing method according to the first embodiment of the present invention.
FIG. 2 is a schematic diagram illustrating pattern image information.
FIG. 3 is a flowchart illustrating how synthesis processing takes place.
FIG. 4 shows red components of main image information.
FIG. 5 is green components of the main image information.
FIG. 6 illustrates pattern image information.
FIG. 7 shows an example of a result of color difference modulation.
FIG. 8 shows red components of a result of superimposition processing.
FIG. 9 shows green components of a result of superimposition processing.
FIG. 10 is a schematic diagram illustrating an example of a synthetic image.
FIG. 11 is a schematic diagram illustrating an example of verification processing.
FIG. 12 is also a schematic diagram illustrating an example of verification processing.
FIG. 13 is a schematic view of first pattern image information according to the second embodiment of the present invention.
FIG. 14 is a schematic view of second pattern image information according to the second embodiment of the present invention.
FIG. 15 illustrates an example of a manner in which main image information is divided.
FIG. 16 illustrates how the divided main image information is synthesized with the first and second pattern image information.
FIG. 17 illustrates red components of main image information.
FIG. 18 illustrates green components of the main image information.
FIG. 19 shows an example of first pattern image information.
FIG. 20 shows an example of second pattern image information.
FIG. 21 is a schematic diagram illustrating a synthetic image.
FIG. 22 is a schematic diagram illustrating a first example of verification processing.
FIG. 23 is also a schematic diagram illustrating a first example of verification processing.
FIG. 24 is a schematic diagram illustrating a second example of verification processing.
FIG. 25 is also a schematic diagram illustrating a second example of verification processing.
FIG. 26 is a schematic diagram illustrating how verification processing is executed.
FIG. 27 illustrates sub image information according to the third embodiment of the present invention.
FIG. 28 is a flowchart illustrating how image synthesis processing is executed on the basis of binary image information.

[0016] Embodiments of the present invention will now be described with reference to the accompanying drawings.

[0017] First, the first embodiment will be described.

[0018] FIG. 1 is a flowchart illustrating the overall flow of the information processing method according to the first embodiment of the present invention. The overall flow of the information processing method will be described, referring to this flowchart.

[0019] In FIG. 1, main image information 101 is a portrait face image used for identification. The main image information 101 is comprised of digital data. It is prepared by reading a photographed portrait face image by scanner input processing 106 or by photographing a person's face by camera photographing processing 107.

[0020] Pattern image information 102, which is sub image information, is prepared either by pattern image input

[0032] First of all, color difference modulation processing step 301 is executed. In this step, the pattern image information 102 is subjected to color difference modulation processing, using the rules expressed by formulas (a-1) and (a-2) set forth below. By this processing, the color difference modulation processing step 301 creates color difference modulation pattern image information. According to the color difference modulation processing step 301, black and white pixels are assigned in accordance with the values of the pixels of the pattern image information 102 in such a manner that a back pixel is assigned to "+1" and a white pixel to "-1." Each of the values is multiplied by a color difference modulation amount ΔV. This color difference modulation amount ΔV is in the range of 0 to 255 and is determined beforehand. In the color difference modulation processing step 301, this processing is executed for each pattern image information 102. FIG. 7 shows an example of a result of color difference modulation 102'.

$$CDMP(i,j) = (+1)^{*}\Delta V \cdots\cdots \text{when } PAT(i,j)=(\text{black}) \tag{a-1}$$

$$CDMP(i,j) = (-1)^{*}\Delta V \cdots\cdots \text{when } PAT(i,j)=(\text{white}) \tag{a-2}$$

where CDMP(i,j) represents the value the color difference modulation pattern image information takes at the position indicated by (x=i, y=j), PAT(i,j) represents the value the pattern image information takes at the position indicated by (x=i, y=j), and Δv represents a color difference modulation amount.

[0033] The color difference modulation amount ΔV is an integer in the range of 0 to 255 ad is determined beforehand. The larger the color difference modulation amount Δv is, the higher will be the visualization contrast at the time of verification. In this case, the verification is easy, but the synthetic image information is liable for adverse effects and may result in poor image quality. Hence, it is desirable that the color difference modulation amount ΔV be within the range of 16 to 96. In the present embodiment, ΔV = 48.

[0034] In a superimposition processing step 302 subsequently executed, the color difference modulation pattern image information obtained in the processing described above is synthesized with the main image information 101 prepared beforehand, so as to obtain synthetic image information 103 (103R, 103G, 103b). In the superimposition processing step 302, superimposition processing indicated by the formulas (b-1) to (b-3) set forth below is executed.

$$DES\text{-}R(i,j) = SRC\text{-}R(i,j) + CDMP(i,j) \tag{b-1}$$

$$DES\text{-}G(i,j) = SRC\text{-}G(i,j) - CDMP(i,j) \tag{b-2}$$

$$DES\text{-}B(i,j) = SRC\text{-}B(i,j) - CDMP(i,j) \tag{b-3}$$

where DES-R(i,j) represents the value the synthetic image information takes at the position indicated by (x=i, y=j) (red components), DES-G(i,j) represents the value the synthetic image information takes at the position indicated by (x=i, y=j)(green components), DES-B(i,j) represents the value the synthetic image information takes at the position indicated by (x=i, y=j) (blue components), SRC-R(i,j) represents the value the main image information takes at the position indicated by (x=i, y=j) (red components), SRC-G(i,j) represents the value the main image information takes at the position indicated by (x=i, y=j) (green components), and SRC-B(i,j) represents the value the main image information takes at the position indicated by (x=i, y=j) (blue components).

[0035] DES-R(i,j), DES-G(i,j) and DES-B(i,j) are integers in the range of 0 to 255. That is, if a result of calculation is less than "0", it is set to be "0", and if it is greater than "255", it is set to be "255."

[0036] FIGS. 8 and 9 show results of superimposition processing. FIG. 8 indicates the case of red components, and FIG. 9 indicates the case of green components.

[0037] As can been seen from formulas (a-1) and (a-2), the coefficient for the color difference modulation amount ΔV alternately takes the values of "+1" and "-1" in accordance with the cycle of the pattern image information 102. If integration is carried out with respect to one cycle of the pattern image information 102, the values of the colof difference modulation amount cancel each other, and the result of integration is thereby rendered zero. Hence, the following formulas are satisfied with respect to the cycles of the grid of the pattern image information 102.

$$\Sigma DES\text{-}R(i,j) = \Sigma SRC\text{-}R(i,j) \tag{c-1}$$

format, the embedded pattern image information 102 remains the same, and the conversion does not give rise to any problems.

[0047] The synthetic image information 103 is printed or recorded by a high-resolution color printer (e.g., a dye-sublimation type thermal transfer printer), and the resultant information is pasted on an ID card or the like. Therefore, a system that determines whether or not the ID card 105 is authentic, checks the information embedded in the synthetic image information 103 pasted on the ID card 105, and determines whether or not the ID card 105 is authentic on the basis of the check. In other words, the pattern image information 102, which is sub image information invisibly embedded in the verification-use face image of the ID card, is sensed to determine whether or not the ID card 105 is authentic.

[0048] The pattern image information 102, which is the sub image information, is sensed by use of the mask sheet 113, and this mask sheet 113 is prepared on the basis of the pattern image information shown in FIG. 6. In terms of the pixel size or pixel position, the mask sheet 113 corresponds to the main image information 101 with a 1:1 relationship. The pattern image information 102 is made up of black patterns and transparent patterns. The black patterns have a value of "1" and do not allow transmission of light, while the transparent patterns have a value of "0" and allow transmission of light. The mask sheet 113 is physically laid over the synthetic image 104 printed on the ID card.

[0049] FIG. 10 is a schematic diagram illustrating the synthetic image 104 in the printed state. Where the synthetic image 104 is prepared on the basis of "uniformly-gray" main image information 101, red and cyan cyclic patterns are embedded as grid patterns. In FIG. 10, the pixels indicated by "R" are pixels that are rich in red, while the pixels indicated by "C" are pixels that are rich in cyan.

[0050] FIGS. 11 and 12 schematically show how the synthetic image 104 shown in FIG. 10 will be when it is overlaid with the mask sheet 113 described above. FIG. 11 shows the case where the synthetic image 104 and the mask sheet 113 are positioned accurately relative to each other. FIG. 12 shows the case where the synthetic image 104 and the mask sheet 113 are shifted from each other by a half period of the cyclic grid pattern. In FIGS. 11 and 12, the pixels indicated with hatchings are those pixels that are masked by the mask sheet 113.

[0051] In FIG. 11, the pixels indicated by letter "R" are masked, and the pixels indicated by letter "C" are observable as being transparent. In this state, therefore, the grid looks like a cyan grid partly covered with a black mask. In FIG. 12, the pixels indicated by letter "C" are masked, and the pixels indicated by letter "R" are observable as being transparent. In this state, therefore, the grid looks like a red grid partly covered with a black mask.

[0052] When the printed synthetic image 104 overlaid with the mask sheet 113 is viewed, what will be observed is the state shown in FIG. 11, the state shown in FIG. 12, or the state intermediate between those shown in FIGS. 11 and 12. When the printed synthetic image 104 is fixed, and the mask sheet 113 is moved vertically or horizontally relative thereto, the states shown in FIGS. 11 and 12 are observed alternately. In other words, the cyan and red grids partly covered with the black mask are alternately observed. Hence, whether the synthetic image 104 is authentic or not can be determined by checking whether or not the red and cyan grids are alternately observed when the mask sheet is moved.

[0053] The relative movement between the printed synthetic image 104 and the mask sheet 113 need not be controlled precisely. Instead of the vertical or horizontal movement described above, a rotational movement may be used. In this case, moiré fringes are observed due to the slight shift between the black grid of the mask sheet 113 and the red or cyan grid which is partly covered. The authenticity determination can be made on the basis of the presence of such moiré fringes.

[0054] A description will now be given of the second embodiment.

[0055] In the second embodiment, the pattern image information 102 serving as sub image information is made by a plurality of pieces (N pieces). Reference will be made to the case where N = 2.

[0056] FIGS. 13 and 14 show two kinds of pattern image information. The first pattern image information 102a is similar to the pattern image information 102 of the first embodiment. The second pattern image information 102b is prepared by rotating the first pattern image information 102a 90 in the clockwise direction.

[0057] Although the case where N = 2 will be referred to in connection with the second embodiment, the number of pieces of pattern image information 102 may be determined arbitrarily. That is, pattern image information that is used as a reference is first prepared beforehand, and then other pieces of pattern image information are prepared by rotating the reference pattern image information by different angles. For example, in the case where N = 3, second and third pieces of pattern image information are prepared by rotating the reference pattern image information 40° and 90°, respectively.

[0058] Next, preparations for synthesis processing 110 are made. As shown in FIGS. 15 and 16, the main image information 101 is divided into N pieces. The manner in which it is divided is optional. In the second embodiment, the main image information 101 is divided into equal pieces, namely, area A (the left half) and area B (the right half). The two pieces 102a and 102b of pattern image information are assigned to these two areas A and B. As shown in FIG. 16, the first pattern image information 102a is associated with area A, and the second pattern image information 102b is associated with area B.

[0059] In the synthesis processing 110, the same method as described in connection with the first embodiment can

[0072] A description will now be given of the third embodiment.

[0073] The third embodiment employs first and second pattern image information 102a and 102b that are similar to those described above in connection with the second embodiment. According to the third embodiment, an area is divided on the basis of the image information (binary image information) representing the binary values (black and white) of characters or symbols, and the first and second pattern image information 102a and 102b are applied to the divisions of the area. As in the first and second embodiments, the main image information 101 may be a photographic natural image, such as a landscape or a face image for identification. The binary image information may be prepared beforehand; alternatively, it may be externally provided when synthetic image information is to be prepared.

[0074] FIG. 27 illustrates an example of a manner in which the first and second pattern image information 102a ad 102b are applied to binary image information 400, which is divided into small areas. In the example shown in FIG. 27, the first and second pattern image information 102a and 102b are applied to images (410 to 419) of numerals "0" to "9" and images (41A to 41F) of alphabetic characters "A" to "F." The image information serving as the binary image information has the same size as an area to be embedded. For example, when numeral "0" is to be embedded in the entire image information, the binary image information representing numeral "0" is first processed in such a manner that it has the same size as the main image information, and then synthesis processing is executed. When binary image information representing a plurality of numerals or symbols is embedded in a partial area of the main image of the binary image information, the binary image information is magnified in such a manner that it is the same in size as the embedding area, and then synthesis processing is executed.

[0075] A description will be given with reference to the flowchart shown in FIG. 28, as to how the image synthesis processing is executed on the basis of binary image information.

[0076] First of all, the binary image information is divided to have desirable dimensions (1 × m) (Step S1). In the example shown in FIG. 27, 1 = 5 and m = 7. The small areas of the divided binary image information are classified by checking whether they correspond to a character or symbol portion or if they correspond to a background portion, which is other than the character or symbol portion (Step S2). Either the first pattern image information 102a or the second pattern image information 102b is assigned to each of the small areas (Step S3). For example, the first pattern image information 102a is assigned to the background portion, which is other than the character or symbol, and the second pattern image information 102b is assigned to the character or symbol portion (the non-background portion).

[0077] After either the first pattern image information 102a or the second pattern image information 102b is assigned, each small area is subjected to the synthesis processing described in connection with the first embodiment (Step S4). By executing synthesis processing for each small area, synthetic image information corresponding to each small area is prepared. All of the resultant synthetic image information corresponding to the respective small areas are merely combined (Step S5).

[0078] By this combination, the synthetic image information, which correspond to the respective small areas, constitute an image having the original size (i.e., the size of the embedding area of the main image information). The synthetic image information of the original size is printed on a recording medium by using a high-resolution dye-sublimation type thermal transfer printer, for example (Step S6). In this manner, an ID card bearing the printed synthetic image information is prepared.

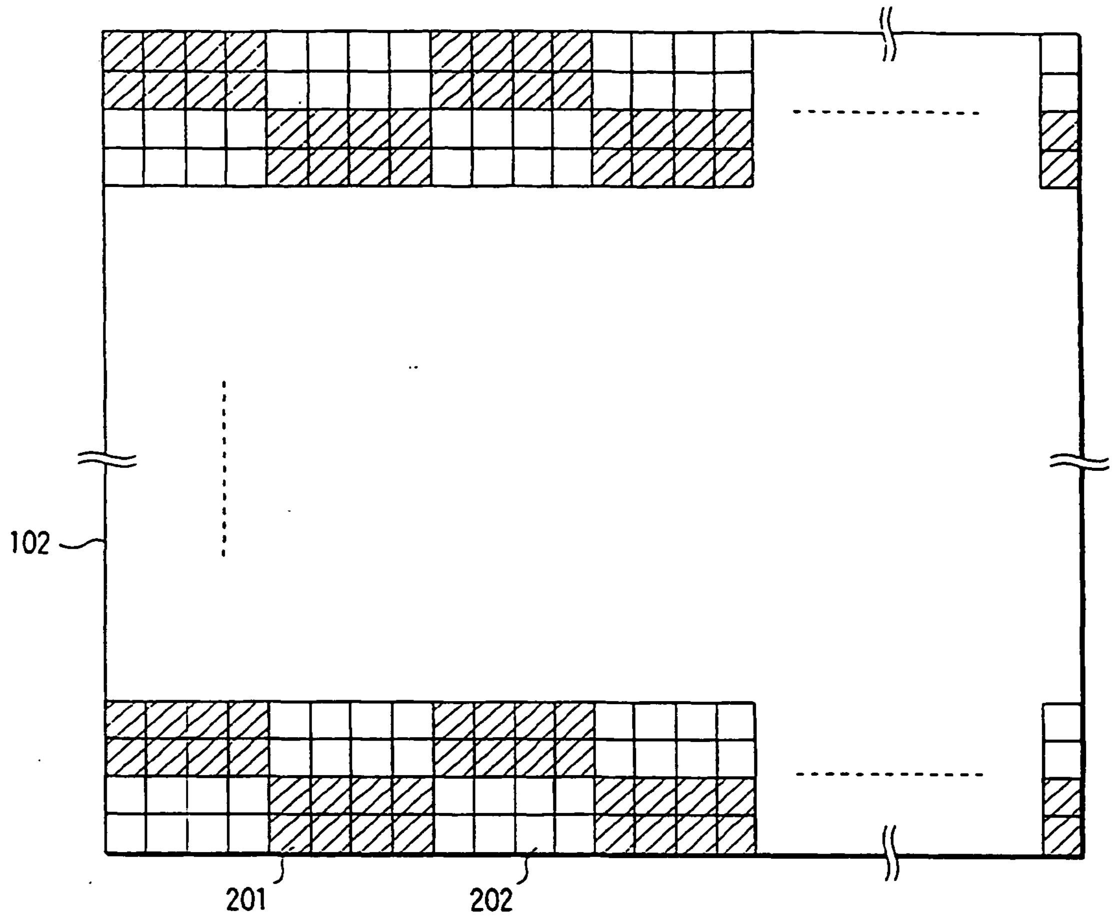
[0079] The synthetic image information prepared according to the third embodiment can be checked for authenticity by using the mask sheet 113a based on the first pattern image information 102a in a similar manner to that of the second embodiment. To be more specific, a mask sheet 113a is prepared beforehand from the first pattern image information 102a. The mask sheet 113a is laid on a synthetic image 104, which is a printed form of the synthetic image information. The printed synthetic image 104 and the mask sheet 113a are moved relative to each other, in such a manner that the relative movement is either linear movement (vertical or horizontal movement) or rotation. After this relative movement, the synthetic image 104 has a contrast between the portions where the first pattern image information 102a is embedded and the portions where the second pattern image information 102b is embedded. The contrast is produced due to the principle described above in connection with the second embodiment. It should be noted that the portions where the second pattern image information 102b is embedded correspond to the background portions of the characters and symbols of the sub image information and that the portions where the first pattern image information 102a is embedded correspond to the non-background portions (i.e., the characters and symbols themselves). Hence, the characters and background of the sub image information are indicated in the synthetic image, with a contrast being produced.

[0080] As can be seen from the above, an authenticity determination can be made by checking whether the embedded sub image information can be visually perceived. According to the third embodiment, moreover, characters or symbols can be embedded in a state that cannot be recognized to the eye of a human being, and the characters, symbols or other embedded information can be sensed in a simple and easy method.

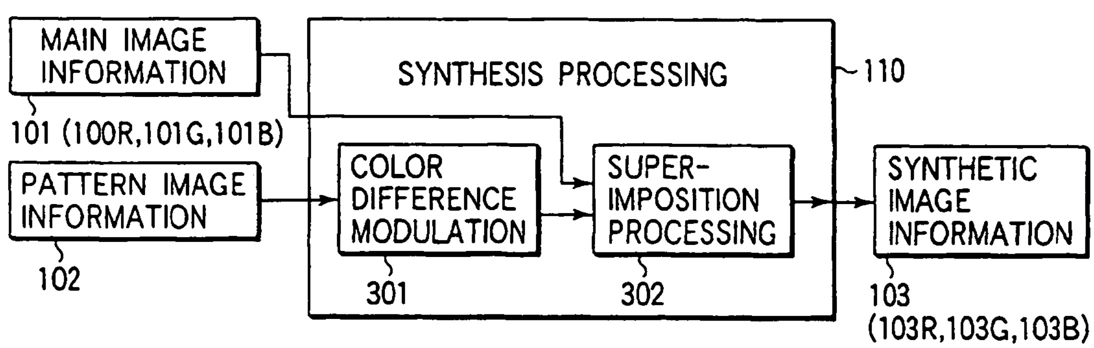
[0081] The information processing method described above enables issuance of an ID card bearing a face image which is for identification use and which provides a high degree of security. Since the information used for authenticity determination is embedded in a state that cannot be recognized to the naked eye of a human being, the main image

(101) such that the first pattern image information (102a) is assigned to an area corresponding binary image information representing a character or a symbol and such that the second pattern image information (102b) is assigned to a background area which is other than the area corresponding to the character or the symbol;
a third step (110) of preparing synthetic image information (103) by synthesizing the sub image information (102) prepared in the second step (108, 109) with the main image information (101) prepared in the first step (106, 107), such that a synthesized state is not recognizable to the naked eye of the human being; and
a fourth step (111) of recording the synthetic image information (103), prepared in the third step (110), on a recording medium (105) as a visible image.

8. An image information processing according to claim 7, **characterized in that** said second step (108, 109) prepares first pattern image information (102a) and second pattern image information (102b), and said second pattern image information (102b) is obtained by rotating the first pattern image information (102a) by a predetermined angle.


102
201
202

F I G. 2


MAIN IMAGE INFORMATION
101 (100R,101G,101B)
PATTERN IMAGE INFORMATION
102
SYNTHESIS PROCESSING
110
COLOR DIFFERENCE MODULATION
301
SUPER-IMPOSITION PROCESSING
302
SYNTHETIC IMAGE INFORMATION
103
(103R,103G,103B)

F I G. 3

PATTERN IMAGE INFORMATION

	0	1	2	3	4	5	6	7	8	9	10	11
0	1	1	1	1	0	0	0	0	1	1	1	1
1	1	1	1	1	0	0	0	0	1	1	1	1
2	0	0	0	0	1	1	1	1	0	0	0	0
3	0	0	0	0	1	1	1	1	0	0	0	0
4	1	1	1	1	0	0	0	0	1	1	1	1
5	1	1	1	1	0	0	0	0	1	1	1	1
6	0	0	0	0	1	1	1	1	0	0	0	0
7	0	0	0	0	1	1	1	1	0	0	0	0
8	1	1	1	1	0	0	0	0	1	1	1	1
9	1	1	1	1	0	0	0	0	1	1	1	1
10	0	0	0	0	1	1	1	1	0	0	0	0
11	0	0	0	0	1	1	1	1	0	0	0	0

102

FIG. 6

COLOR DIFFERENCE MODULATION RESULT

	0	1	2	3	4	5	6	7	8	9	10	11
0	48	48	48	48	-48	-48	-48	-48	48	48	48	48
1	48	48	48	48	-48	-48	-48	-48	48	48	48	48
2	-48	-48	-48	-48	48	48	48	48	-48	-48	-48	-48
3	-48	-48	-48	-48	48	48	48	48	-48	-48	-48	-48
4	48	48	48	48	-48	-48	-48	-48	48	48	48	48
5	48	48	48	48	-48	-48	-48	-48	48	48	48	48
6	-48	-48	-48	-48	48	48	48	48	-48	-48	-48	-48
7	-48	-48	-48	-48	48	48	48	48	-48	-48	-48	-48
8	48	48	48	48	-48	-48	-48	-48	48	48	48	48
9	48	48	48	48	-48	-48	-48	-48	48	48	48	48
10	-48	-48	-48	-48	48	48	48	48	-48	-48	-48	-48
11	-48	-48	-48	-48	48	48	48	48	-48	-48	-48	-48

102'

FIG. 7

	0	1	2	3	4	5	6	7	8	9	10	11
0	R	R	R	R	C	C	C	C	R	R	R	R
1	R	R	R	R	C	C	C	C	R	R	R	R
2	C	C	C	C	R	R	R	R	C	C	C	C
3	C	C	C	C	R	R	R	R	C	C	C	C
4	R	R	R	R	C	C	C	C	R	R	R	R
5	R	R	R	R	C	C	C	C	R	R	R	R
6	C	C	C	C	R	R	R	R	C	C	C	C
7	C	C	C	C	R	R	R	R	C	C	C	C
8	R	R	R	R	C	C	C	C	R	R	R	R
9	R	R	R	R	C	C	C	C	R	R	R	R
10	C	C	C	C	R	R	R	R	C	C	C	C
11	C	C	C	C	R	R	R	R	C	C	C	C

FIG. 10

	0	1	2	3	4	5	6	7	8	9	10	11
0	R	R	R	R	C	C	C	C	R	R	R	R
1	R	R	R	R	C	C	C	C	R	R	R	R
2	C	C	C	C	R	R	R	R	C	C	C	C
3	C	C	C	C	R	R	R	R	C	C	C	C
4	R	R	R	R	C	C	C	C	R	R	R	R
5	R	R	R	R	C	C	C	C	R	R	R	R
6	C	C	C	C	R	R	R	R	C	C	C	C
7	C	C	C	C	R	R	R	R	C	C	C	C
8	R	R	R	R	C	C	C	C	R	R	R	R
9	R	R	R	R	C	C	C	C	R	R	R	R
10	C	C	C	C	R	R	R	R	C	C	C	C
11	C	C	C	C	R	R	R	R	C	C	C	C

FIG. 11

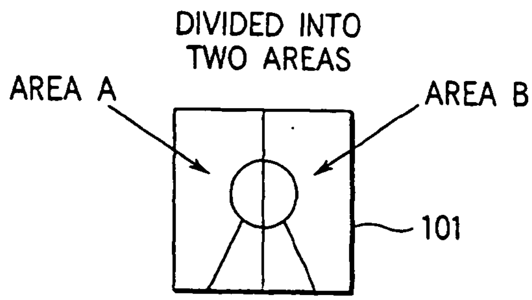

DIVIDED INTO
TWO AREAS
AREA A
AREA B
101

FIG. 15

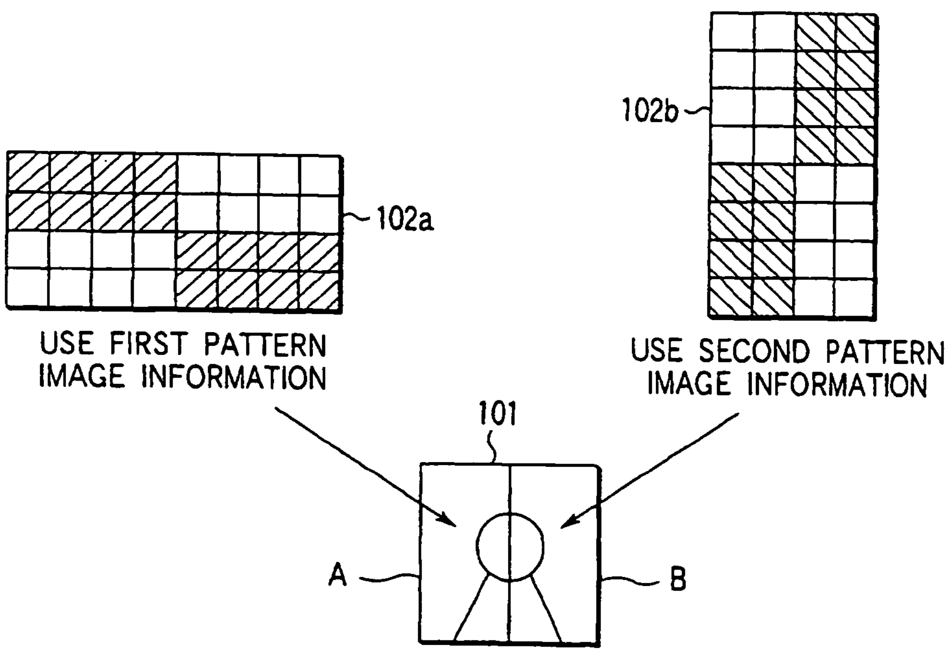

102b
102a
USE FIRST PATTERN
IMAGE INFORMATION
USE SECOND PATTERN
IMAGE INFORMATION
101
A
B

FIG. 16

FIRST PATTERN IMAGE INFORMATION

	0	1	2	3	4	5
0	1	1	1	1	0	0
1	1	1	1	1	0	0
2	0	0	0	0	1	1
3	0	0	0	0	1	1
4	1	1	1	1	0	0
5	1	1	1	1	0	0
6	0	0	0	0	1	1
7	0	0	0	0	1	1
8	1	1	1	1	0	0
9	1	1	1	1	0	0
10	0	0	0	0	1	1
11	0	0	0	0	1	1

102a

F I G. 19

SECOND PATTERN IMAGE INFORMATION

	0	1	2	3	4	5
0	0	0	1	1	0	0
1	0	0	1	1	0	0
2	0	0	1	1	0	0
3	0	0	1	1	0	0
4	1	1	0	0	1	1
5	1	1	0	0	1	1
6	1	1	0	0	1	1
7	1	1	0	0	1	1
8	0	0	1	1	0	0
9	0	0	1	1	0	0
10	0	0	1	1	0	0
11	0	0	1	1	0	0

102b

F I G. 20

	0	1	2	3	4	5	6	7	8	9	10	11
0	R	R	R	R	C	C	C	C	R	R	C	C
1	R	R	R	R	C	C	C	C	R	R	C	C
2	C	C	C	C	R	R	C	C	R	R	C	C
3	C	C	C	C	R	R	C	C	R	R	C	C
4	R	R	R	R	C	C	R	R	C	C	R	R
5	R	R	R	R	C	C	R	R	C	C	R	R
6	C	C	C	C	R	R	R	R	C	C	R	R
7	C	C	C	C	R	R	R	R	C	C	R	R
8	R	R	R	R	C	C	C	C	R	R	C	C
9	R	R	R	R	C	C	C	C	R	R	C	C
10	C	C	C	C	R	R	C	C	R	R	C	C
11	C	C	C	C	R	R	C	C	R	R	C	C

AREA A ⟵ | ⟶ AREA B

F I G. 23

	0	1	2	3	4	5	6	7	8	9	10	11
0	R	R	R	R	C	C	C	C	R	R	C	C
1	R	R	R	R	C	C	C	C	R	R	C	C
2	C	C	C	C	R	R	C	C	R	R	C	C
3	C	C	C	C	R	R	C	C	R	R	C	C
4	R	R	R	R	C	C	R	R	C	C	R	R
5	R	R	R	R	C	C	R	R	C	C	R	R
6	C	C	C	C	R	R	R	R	C	C	R	R
7	C	C	C	C	R	R	R	R	C	C	R	R
8	R	R	R	R	C	C	C	C	R	R	C	C
9	R	R	R	R	C	C	C	C	R	R	C	C
10	C	C	C	C	R	R	C	C	R	R	C	C
11	C	C	C	C	R	R	C	C	R	R	C	C

AREA A ⟵ | ⟶ AREA B

F I G. 24

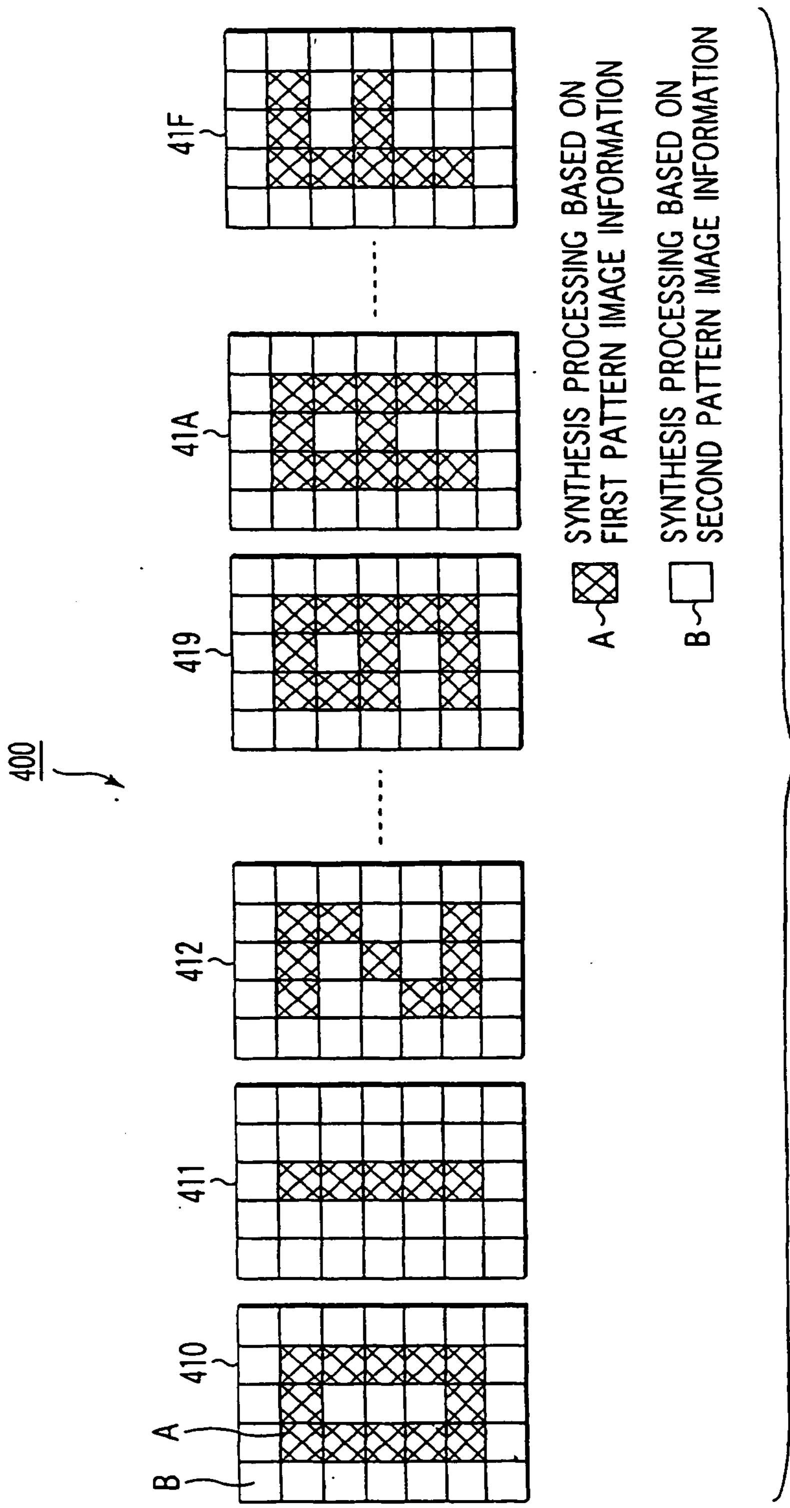

400
B
A
410
411
412
419
41A
41F
A
SYNTHESIS PROCESSING BASED ON FIRST PATTERN IMAGE INFORMATION
B
SYNTHESIS PROCESSING BASED ON SECOND PATTERN IMAGE INFORMATION

FIG. 27